ONE WORLD TRADE CENTER FIRE

New York, N.Y.
February 13, 1975

HIGH-RISE FIRE SAFETY

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ONE WORLD TRADE CENTER FIRE

New York, N.Y.

FEBRUARY 13, 1975

The early morning news reports on Friday, February 14, 1975 set the minds of all fire buffs in the New York metropolitan area to feverish activity. Fire was reported in the North Tower from the 9th to the 19th floor. The possible consequences and solutions radiated throughout the area. Suppose 6,000 people have to go to the roof, with flames licking up the stairs, elevators and windows. How can they be rescued? The French tight-rope walker showed how easy it was to do this. Get a bow and arrow and shoot a fishing line from the South Tower to the North Tower. Pull a heavier line and then a steel cable between the two roofs. A breeches buoy then could make a round trip every minute carrying one of the trapped occupants to safety. EVERY MINUTE!! With 6,000 people waiting, that would take 100 hours or over four days. The last survivors would be dead of starvation if they managed to survive the advancing flames.

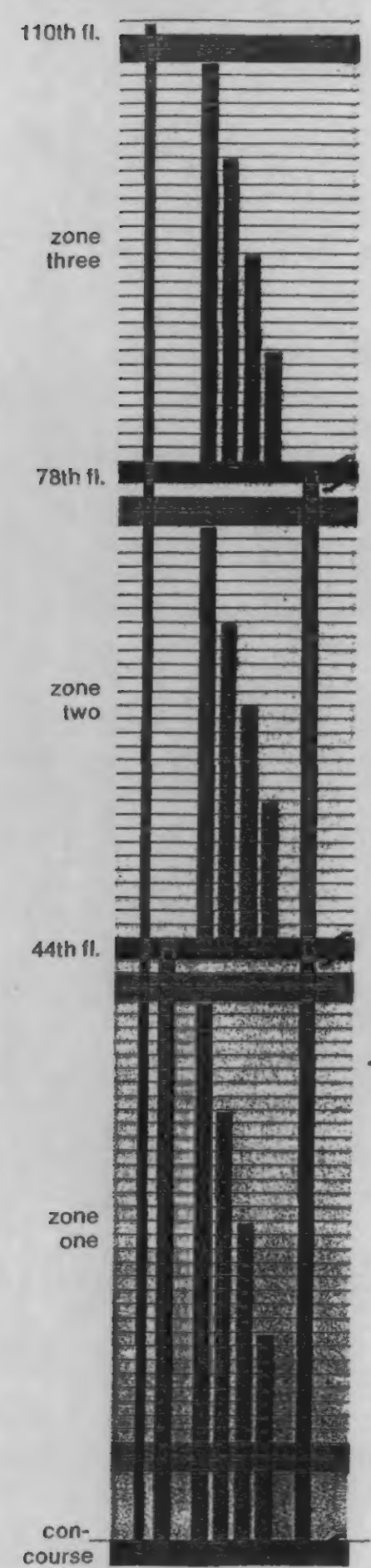
There must be a better way

The most commonplace solution that flashed through peoples' minds to rescue the imagined trapped 6,000 was by means of helicopters. A phone call to New York Airways would bring two of their thirty passenger helicopters to pick the people off the roof and deposit them safely at Battery Park only a few blocks away. Since a copter could make the round trip in five minutes, two of them could save 720 people per hour. The whole 6,000 could be removed in 8-1/2 hours which is a long time when flames are singeing your feet. Besides, this plan ignored the T.V. transmission antenna being erected on the roof, the winds that always blow at the 110th story, and the danger of engine failure because of smoke and heat.

There must be an even better way.

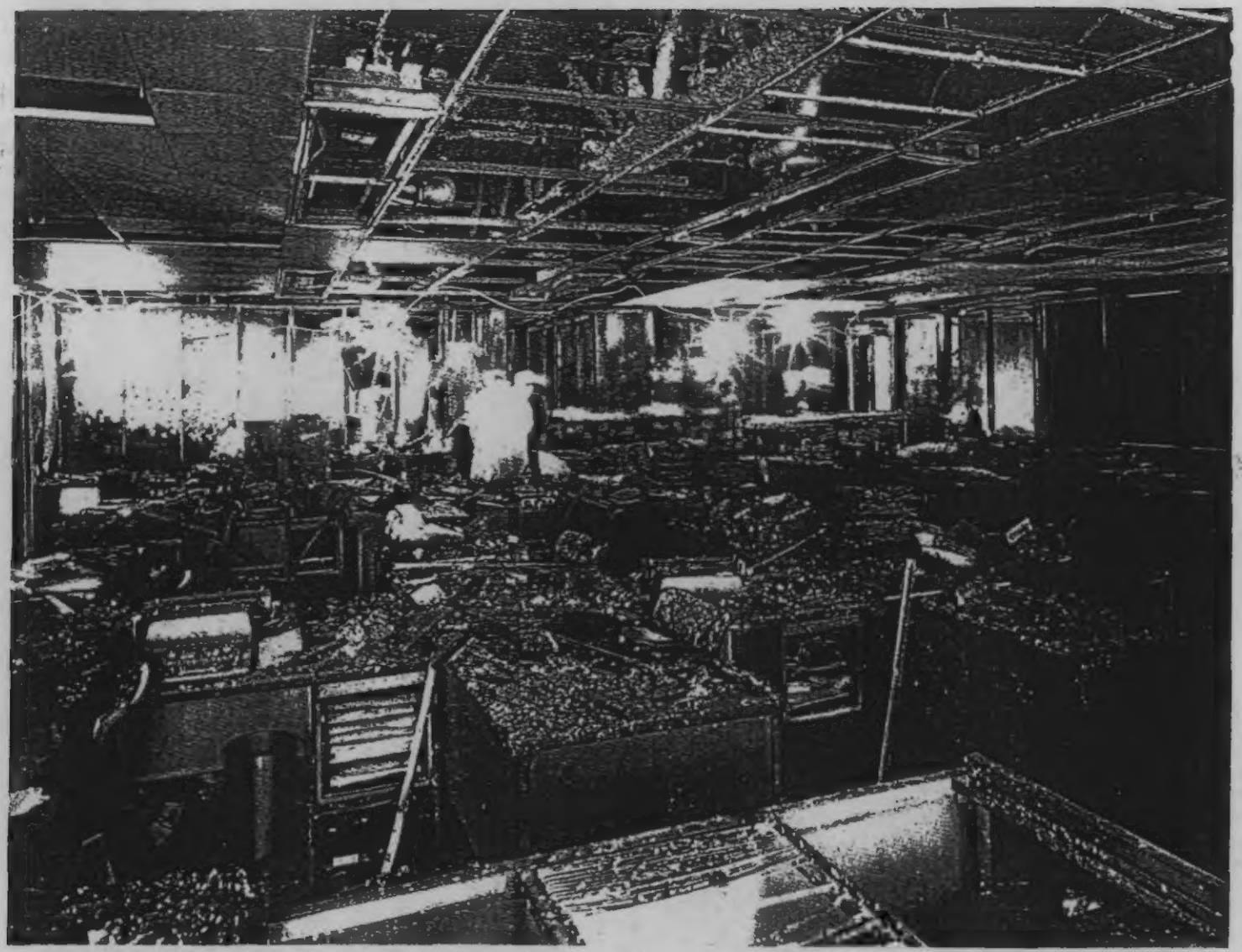
Fortunately, there were no trapped occupants on the roof during this fire and there certainly is a better way to safeguard the tenants. A study of the fire and the World Trade Towers is necessary to comprehend the better way.

About 11:35 P.M. on Thursday, February 13, 1975, a porter finished his chores on the 12th floor and took the elevator to the 11th floor. After working about ten minutes, he heard a crackling sound and saw flames under the door leading to the R. J. Saunders' office. He turned in the fire alarm to the World Trade Police Headquarters and told them of the fire on the 11th floor. The Police put into effect the planned fire procedure: the city fire department was called, three policemen with a fire equipment cart went to the fire floor and the engineer was advised to be prepared to put the air conditioning on the purge mode. One minute after the manual alarm was received, the smoke detector in the air conditioning plenum at the southeast corner of the 11th floor operated. The smoke detectors at the same relative positions on the 19th to 12th floors, except for the 15th floor operated successively at about one minute intervals. In the meantime, the police, wearing air packs, reached the 11th floor and found the door to the Saunders' office too hot to open. They used a standpipe hose from a nearby stairway to try to cool the door. They had reported via Walkie Talkie, of the serious fire and the air conditioning was placed in the purge mode. This means that fresh air was being blown into the core area to keep it free of smoke and air was being drawn out of all the tenant areas on this floor to prevent smoke from spreading throughout the building. The fire department arrived promptly and spread hose lines to bring the fire on the 11th floor under control. This was a hot and stubborn fire to extinguish. It was not recognized immediately that fire had spread to other floors but a search disclosed fire coming out of the vent in the telephone closet door on the 12th and 13th floors, igniting files in these office areas. This discovery caused the fire department to order evacuation of all the cleaning and service personnel in this building. Further search showed that the fire had extended to telephone closets on the 9th through 19th floors. These fires were readily extinguished. The fire involved about 9,000 square feet of the 11th floor, destroying about half the contents and damaging the remainder in this area. It completely burned out the telephone panels and wiring in the telephone closets on three floors and caused severe damage in eight others. Four steel bar trusses were distorted slightly.



Schematic view of Tower building elevators shows how express and local runs are separated.

Key
- Express to Club floor
- 23 express elevators to skylobbies
- 72 local service elevators
- Skylobby floors
- Mechanical floors
- Escalators
- Floor stops



R. J. Saunders office on 11th floor file room is at left and office of fire origin is behind partition at right of picture.

During a fire, it is extremely difficult to determine details on causes and effects. The prime consideration is to extinguish the fire. As soon as the smoke had cleared and for many days later, a detailed study was made to determine the origin and reasons for the spread of the fire.

R. J. Saunders occupied the southeast corner of the 11th floor of the North Tower, known also as Tower A or 1 World Trade Center. At the north end of their space there was an executive office furnished with a wooden desk and credenza, sofa, four chairs and two lamp tables. Cushioning for the sofa and chairs was foamed-polyurethane with dacron covering. The rug was wool pile on rubberized felt. The remainder of the floor contained other private offices and open office area with the usual desks, chairs and files, a file room and lunchroom. It was determined that on the day of the fire the last employee of R. J. Saunders left this office about 9:30 P.M. and the cleaning woman left about 10:30 P.M. Both reported conditions normal when they left. The cleaning woman does not smoke. It is believed that the fire originated in the executive office from some unknown source at about 11:30 P.M. The overstuffed furniture burned fiercely and fire spread south and west along corridors toward the open office area. The fire entered the file room where numerous records were stored on narrow shelves, some with steel shutters. Unfortunately, all of the shutters were open. A gallon can of methyl-alcohol duplicating fluid in this room was set aflame by the heat. It appears that a flashover occurred just as the Port Authority policemen reached the office door, driving the fire out of the office of origin, and breaking seven windows in the east wall. Fresh air to fan the fire entered the 11th floor through these broken windows. The outer skin of the building suffered no smoke or heat damage because this airflow was inward. Fire also spread through the horizontal channel in the peripheral heat diffuser units to adjoining offices north and south of the office of origin. At about the same time the windows broke, the air conditioning was placed in the purge mode and the exhaust fans pulled air into the plenum to the return air duct at the

southeast corner of the core. It should be noted that the air conditioning is not operated at night so there was no movement of air via this system prior to this purge. Telephone cables in the plenum were ignited by the fire. Because of openings around the cables where they passed through the telephone closet walls and because of louvers in the telephone closet door, fire penetrated the closet to ignite telephone panel blocks and cables. Fire spread to upper and lower levels through openings about 12" x 18" in the floors of these closets. Cables passed vertically through these openings but no firestopping was provided for spaces around the cables. The polyethylene and polyvinyl chloride cable insulation and plastic panel blocks burned readily so that virtually all combustibles including the fire retarded wood panelling on the telephone closet walls of the 10th and 12th floors was destroyed. Fire emerged from the telephone closets on the 12th and 13th floors in the same manner it entered on the 11th floor. Fortunately, there were relatively small amounts of combustibles near the closet doors on these floors so that the fire department had no trouble controlling these blazes. Meanwhile, back on the 11th floor, the heated gas reached the return air outlets at the southeast air conditioning shaft, fusible links melted and closed the shutters to the shaft. Smoke and fire gases could not pass into the southwest quadrant of this floor because a one-hour fire partition had been erected at the west end of the Saunders' office to subdivide the floor area in accordance with New York City Local Law #5. Some heated gas was being drawn around the core to the northeast and northwest return air outlets but closing of these protective dampers at the southeast shaft now caused all of the fire gases to flow to the north end of the building. Eventually, the fusible link on the shutter at the northeast shaft operated and closed the shutter to the shaft here but it is believed that the fire was under control at this point. However, high temperatures in the plenum radiated enough heat into the offices to the north of the fire to melt plastic phones and char papers on desk tops, but ignition did not take place. The fire in the file room was of particular interest because of intense burning at opposite ends of the file room. It appeared at first that the fire originated in this section but further investigation showed that the intense fire at the east end of the room could be attributed to the flammable duplicating fluid and at the west end of the room to proprietary telephone equipment with plastic insulated cables and components, construction debris, file storage, and other combustible storage. A question raised after the fire was why the smoke detector in the plenum at the south east return air shaft did not operate earlier. Since the fire started at the opposite end of the office and the air conditioning was shut down, no air was being drawn past this

Proprietary telephone cabinet located at west end of file room on 11th floor.

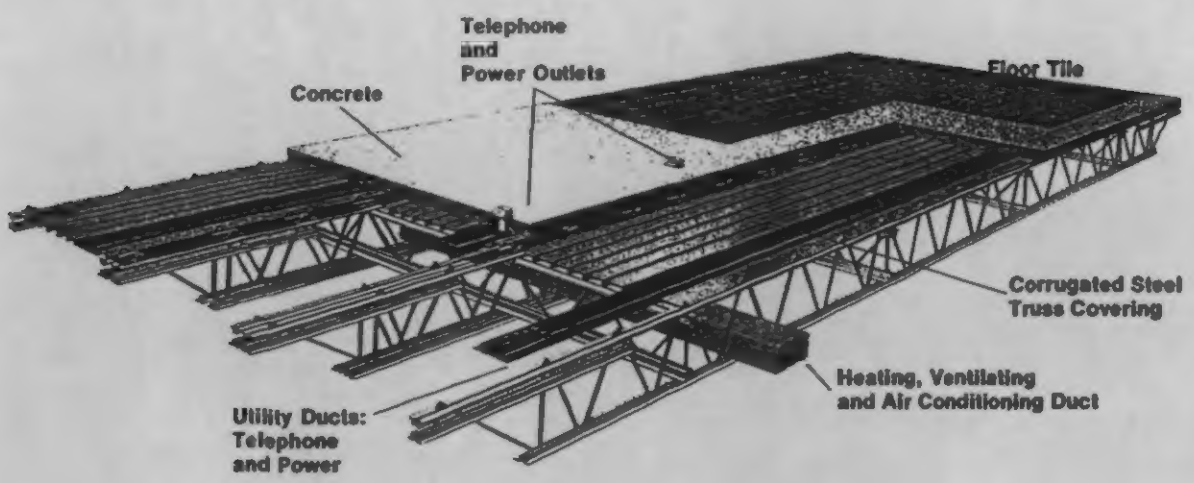
detector. Smoke had to enter and spread through the plenum to the western end until a sufficient amount entered the detector to cause it to send an alarm.

Considerable discussion ensued after this fire as to its effect on occupants if it occurred during working hours. It also raised the question as to whether more fires could take place which could threaten the thousands of people located throughout 110 floors. The World Trade Center is unique in many respects but has sufficient points in common with all high-rise office buildings that its story is applicable everywhere. Construction hazards and protection can be evaluated for other buildings based on these towers.

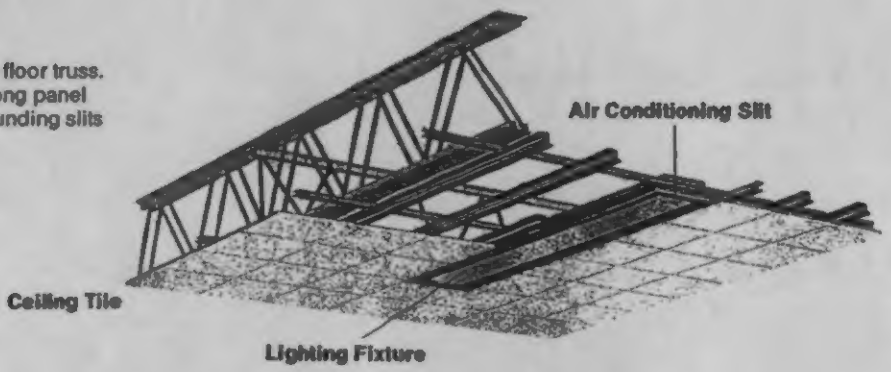
The twin towers of the World Trade Center, each 209 feet square and 1350 feet tall rise about a five acre open plaza. There will be four low-rise buildings surrounding this plaza to complete this project. Only the Twin Towers will be discussed in the following description. Construction of these towers is unique in that the exterior walls are load-supporting walls. Large steel trusses connected to the interior core are structurally a part of the 4" concrete floor they support. The core, which contains elevators, stairs, rest rooms and building services, consists of numerous

Floor and Ceiling Construction:

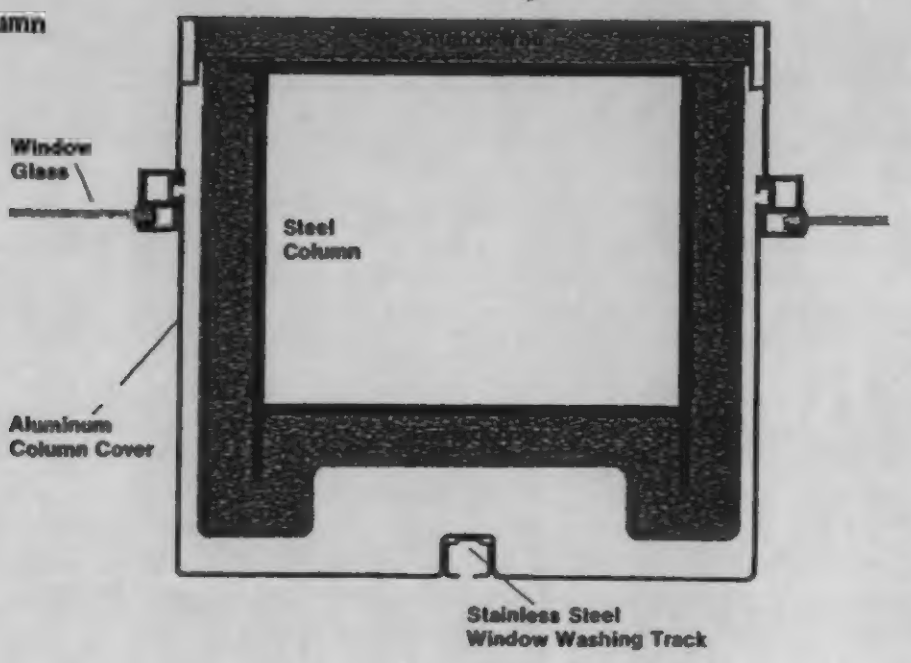
Floor truss in close-up detail. Following placement of truss, the corrugated top was covered by concrete floor slab and tile surface. Underneath, a network of utility and air conditioning ducts traverse the 32-inch deep-cavity.



Looking upward at the same floor truss. Ceiling tile is in place. The long panel provides lighting, with surrounding slits for air conditioning.



Exterior Wall Column
(Plan view)



steel columns with concrete floors. The area between the core and the outerwalls is column-free on the lower levels providing about 30,000 square feet of clear office space. Concrete in the core was poured on forms while in the remainder of the building, fluted steel forms were used. These concrete floors butt against the exterior steel spandrel beam so no vertical flues are formed. In addition, the interior face of the exterior columns is protected by plaster so that no vertical flue exists at this point. The spandrel beam is sprayed with vermiculite plaster to provide the vertical fire separation between windows. The steel bar trusses and interior columns are protected with Cafco Type D sprayed fibre to protect them from fire. All vertical shafts are enclosed by 2-hour fire rated walls consisting of 2 one-inch thick sheets of gypsum plank between H channels and one layer of 5/8" plank on one or both sides. The fluted steel forms have no fire protection on the underside except that a five foot wide strip of sprayed fibre has been applied under the trench headers.

The basic fire protection consists of standpipes with hose and two fire extinguishers in each of the three stair towers. Water supply for the standpipes is from 5,000 gallon tanks on four levels, two-750 g.p.m., 228 pounds in the basement taking suction from city water mains and one-750 g.p.m., 228 pound pump at the first three tank rooms. Only two pumps in series are required to provide the pressure needed to reach the top of the tower.

There is a manual fire alarm box on each floor that provides two-way communication with the Police Desk in the basement.

At the time of the fire PYR-A-LARM Smoke Detectors were being installed at the return air outlets in the four quadrants of each floor. This installation is now complete. These will sound an alarm and identify their location at the Police Desk. In addition, operation of these smoke detectors will shut down the air conditioning system.

The watchman service consists of three guards who patrol all floors of the building during non-working hours as well as uniformed police stationed at various posts throughout the World Trade complex.

Some floors or sections of floors have been sprinklered, including all restaurants not under Port Authority ownership. Sprinklers have not been provided in Port Authority restaurants because the furnishings meet their flammability standards. Hoods in all kitchens are equipped with automatic fire protection of various types.

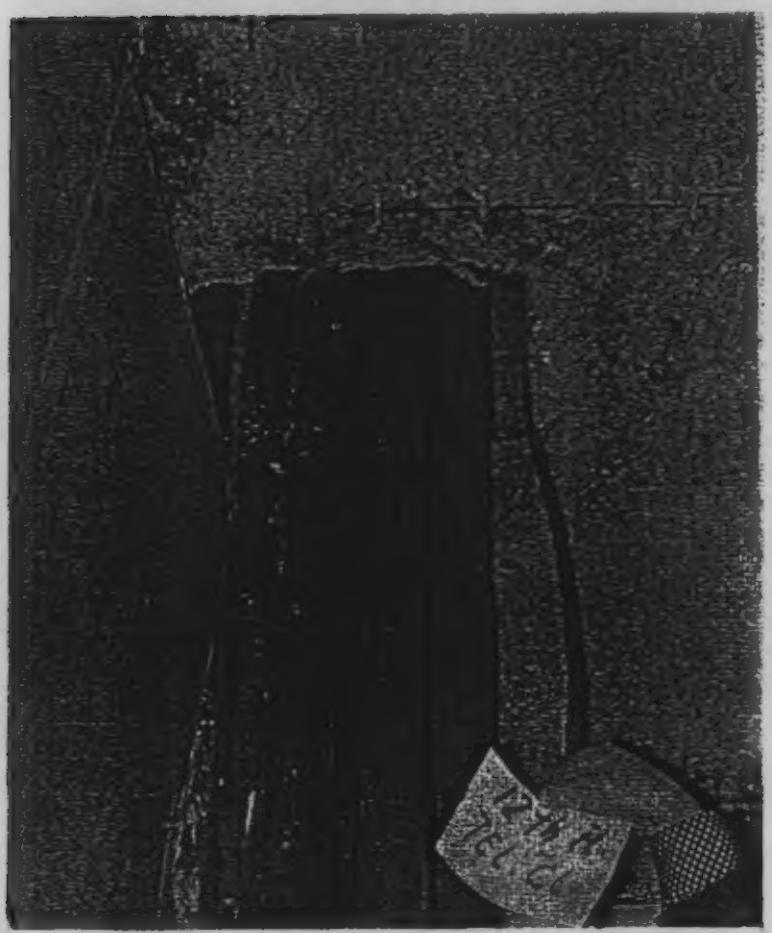
Further description of the building requires the use of various plans to simplify understanding on the arrangement. While the casual outsider sees two towers stretching skyward, a closer look would show that each building is divided into three vertical sections about 32 stories high by the mechanical equipment rooms. Tenants would consider the building to be three units because of the sky lobbies where they transfer from express to local elevators. Elevator engineers might consider each tower to be a series of seven and eight story buildings because this is the number of floors served by individual elevator banks. None of these concepts are correct because of overlapping of the various supposed zones.

As shown in the plan on page 4, sky lobbies are located at the 44th and 78th floor levels. Express elevators carry passengers to either sky lobby which functions the same as the ground floor lobby. There are four banks of elevators for each segment serving six or seven floors and having no openings into other floors. This is an important feature because evacuation during a fire could be carried out by the use of all elevators except for the bank that has openings to the fire floor. There is one elevator which stops at all floors and is set aside for fire department use during an emergency. The air conditioning system actually divides the building into four vertical sections. Fan rooms on the 7th, 41st, 75th and 108th floors provide air conditioning for floors 1 to 24, 25 to 58, 59 to 91 and 92 to 106 respectively. The air conditioning shafts located at the four corners of the core contain air supply ducts which carry air to the peripheral units, located under the windows, to the office ceiling discharge outlets and to the core. The balance of the air conditioning shaft acts as the return air passage. The supply duct for the window unit passes through the plenum of the floor below and through a hole in the floor to the units above. The space between the hole and the duct has been packed with fiberglass batting. This firestopping is of questionable reliability. There is no recirculation of air from the core; it is exhausted through lavatory vents and other means. Air from window and ceiling supply units passes through the office space to outlets in the hung ceiling so that the concealed space acts as a plenum. Steel leaf shutters, equipped with fusible links, are provided at each opening to the air conditioning shaft. In addition, one smoke detector is located in the plenum near the return air openings into the shaft. In the mechanical equipment rooms smoke detectors are provided on both sides of the fan as well as a thermal detector on the downstream side of the filter.

Telephone, power and pipe shafts are located in the outer section of the core. Power shafts have louvered doors for air circulation and have a single wall vent equipped with an automatic shutter which leads to a separate vent duct. Wiring is in conduit or vented bus ducts with fire stopping at each floor and openings around conduits in walls and floors are fire-stopped with plaster and mortar.

Telephone shafts have louvered doors also but no planned outlet openings. Cables insulated with

polyethylene and polyvinyl chloride pass through an opening in the ceiling about 12" x 18" to the closet above and through holes in the wall to other telephone closets on the same floor. None of these openings were fire stopped in the North Tower and these openings were the cause of the fire spreading vertically from one closet to another. The holes in the closet walls allowed fire to enter these closets on the 11th floor and enter the plenums on the 12th and 13th floors. The openings in the shaft created a flue from the 9th to 20th floor with ample combustibles in each closet to produce an intense fire. Since the fire, all of these openings have been firestopped with fiberglass batts. As a contrast the floor openings in the South Tower were effectively fire stopped by concrete poured into forms around the cables and extending about two inches above the floor. Permanent fire stopping of vermiculite concrete is being installed in place of the temporary expedients. The louvers in the door to the telephone closets will be sealed with a steel plate.



Telephone cables passing through opening in closet floor. Fire damaged cables have been replaced. Note the spalling of concrete.

However, two unsatisfactory conditions remain in connection with the telephone installation. Cables passing from one closet to another closet on the same floor pass through the plenum above the hung ceiling. The exposed cable insulation is combustible and constitutes a hazard because fire will be drawn into the plenum and the insulation will intensify the fire at this point. The second point is where the telephone cables pass through the mechanical equipment levels. Large groups of plastic insulated cables pass through one of the air handling rooms for the air conditioning system in a location where fire in the cables could spread smoke to as many as 32 floors. Smoke detectors at the filters would prevent this smoke from being recirculated but would not prevent smoke travel through the shafts when the system was shut down.

Any discussion of the World Trade Center would be incomplete without mentioning two unique fire safety features, their limits on contents combustibility and their fire safety plan. In 1970 before the first tenants moved into the building, the Port Authority Safety Department recognized the hazard of combustible furnishings, especially foamed plastic cushioning for chairs and sofas. Specifications for flammability of furnishings were developed which are adhered to in Port Authority and New York State Offices and are urged for use in other tenants' offices. Briefly, these recommendations ask that chairs be no more hazardous than red oak, that is, have a flame spread rating of not over 100, that upholstery materials, drapes and curtains be self-extinguishing as defined by Federal Specification CCC-T-191 b Method 5903 and that carpets have a flame spread rating of not over 25 in exits, 75 in corridors, 100 in general areas over 1,000 square feet and 150 in general areas less than 1,000 square feet. These recommendations do not call for completely non-combustible furnishings, but limit the fire hazard to prevent extremely rapid combustion.

The Fire Safety Program of the World Trade Center is an excellent one. It should be, since 50,000 tenant workers and 65,000 visitors each day are anticipated in this complex. There is a full time Fire Protection Engineer and five Fire Safety Directors, trained and certified by the New York City Fire Department, for this Center during the day. At night there are two Fire Safety directors. Their duty is to control fire fighting, notify tenants of conditions and guide evacuation until the fire department takes control. In addition, there is an initial fire brigade of three trained policemen to respond immediately to each alarm with a fire-fighting cart containing extinguishers, air packs, resuscitators and first aid kit. Communication between units is maintained by Walkie-Talkies carried by all of these men and furnished to the Fire Department on arrival. This is not just a paper organization since fire drills are held every three months with every tenant and its wardens participating. Once a year informatory sessions are held to update tenants on the latest fire prevention information.

Of prime importance are the fire drills held the first Sunday of every month by the New York City Fire Department. Fire trucks roll into the basement loading area, the chief-in-charge tells the firemen where the fire is and the firemen respond with hose and nozzles to the supposed fire location. The World Trade Police and fire crew also participate by carrying out their assigned functions. The same crews are not brought in every week, but second and third alarm companies in remote locations also drill in case they must respond to the Center. Needless to say, the Fire Department is well acquainted with the building layout, stairs, elevators, and protection features so that their operation in a real fire emergency can be swift and sure.

The final feature to be examined is compliance with New York City Local Law No. 5, Fire Safety in High-Rise Buildings. This Law, very generally speaking gives a building owner the option of providing automatic sprinklers or providing a series of other alternatives.

1. The Law requires large floor areas to be subdivided into 7,500 square feet compartments by one-hour partitions. This is in the process of being done except where a tenant wants a large open area, the entire floor is sprinklered.

2. The Law requires that stairs be pressurized or an automatic smoke evacuation system provided. The World Trade Center has provided a combination of both methods. In case of fire, the supply air fans for the air conditioning section are shut down and only the return air fans operate and discharge to the outside of the building. Unfortunately, laws and standards require a shutter with a fusible link at the return shaft which will close off this shaft in event of fire. This causes the products of combustion to flow to return air shafts in other quadrants and would tend to spread the fire to other sections of the floor. This shutter could remain in an open position if provisions are made to prevent fire from entering other floors through the return air shaft. Tests at 30 Church Street by the New York City Fire Department, showed that an abnormal temperature would not exist in the return air shaft because of the large volume of cool air being drawn in from other floors. The other part of this protection is achieved by supplying fresh air to the core and shutting down its normal vents. This pressurizes the elevators as well as the stairs and keeps the exit corridors free of smoke. It was found during the last fire that this feature worked very well. A pressure differential of at least .03 inches of water can be maintained, which in connection with directing the fire to the return air shafts provides the results desired by Local Law No. 5.

3. The Law requires that smoke detectors be provided on each floor at each return air shaft. This was in process of installation at the time of the fire and is now complete on all occupied floors.

4. The Law requires a manual fire alarm and communication system that provides two-way communication with the fire wardens on every floor and a public address system to communicate with the tenants on one floor or any series of floors. The alarms and loudspeakers are installed in corridors but the alarm to office areas is now given by blinking the fluorescent lights. A public address system will be installed in the future.

5. The Law requires smoke detectors in all elevator lobbies to send elevators to the ground floor or sky lobby on actuation. This has not been installed as yet but will be done. At present there is a manual switch in each lobby and one is being installed at the Police Desk to bring the elevators down to a lobby level.

6. It is required that interlocks on elevators be wired with high temperature wire and equipped with a fireman's switch that gives a fireman complete control of the elevator. This has been done and one elevator that serves all floors is being designated for fire service.

7. It is required that there be floor wardens, fire safety directors, fire command centers and evacuation drills with tenants. This has been done.

Many people have asked — "How Safe Are The Two World Trade Towers?" Realizing that about 65,000 people may be in one tower at any height from ground level to 1,350 feet, it is obvious that there is no margin for error. In the overall, these towers may be considered as among the safest buildings in New York City. There are bad points about these towers; — fireproofing of the steel may be missing in places; openings have been made in floors and walls, but it must be said that the World Trade Officials reacted quickly to fire stop these openings; fire rating of shafts is just above minimum requirements; wiring ducts under the floor (as in many other buildings), have questionable fire resistance and construction hazards and deficiencies due to incomplete construction are still present.

However, the good points outweigh the bad: —

Limited combustibility of furnishings is a proper point to start. If tenants would support these recommendations, the chance of a serious fire would be small.

Good vertical protection between windows and at the junction of the outer wall and floor slab.

Non-combustible building components including thermal insulation.

Ability to vent smoke and pressurize core.

Control panel in World Trade Police Headquarters. Fire Alarms are received here and are transmitted to Fire Department via alarm box here or by "Hot Line" telephone.

Automatic sprinkler protection in basements, shops, and special hazard

The presence of trained Fire Safety Directors and Police for fighting fires, as well as drills with the New York City Fire Department furnishes competent control in case of fire.

Last and perhaps least understood is the building arrangement. The building is subdivided into many vertical components so that the possibility of total involvement in fire is almost impossible. There are only three vertical shafts that travel the height of the building. Only one of these has openings on every floor and is designated for fire department use. The other two elevator shafts have openings only at ground floor, the sky lobbies, and in the upper third of the building. The chimney effect so often mentioned in high-rise buildings will not be 110 stories in effect, but will be divided into four components by the action of the air conditioning systems. None of the stairs run straight from the top to the bottom of the building. Stair towers are offset at various floors where the size of the core changes or the number of elevators serving a floor is reduced. At each of these points, horizontal passageways lead to the new shaft location and fire doors are provided in the passageway. These doors would prevent smoke from contaminating a stairway from top to bottom. The arrangement of elevators is such that the elevators would not provide a means of carrying fire throughout the building but could only be a factor in a limited number of floors. As stated earlier, the arrangement of elevators would make it possible to use elevators for evacuation except for the seven or eight floors served by the elevators which served the fire floor.

In the first paragraphs, the need for a better way to save people trapped in a fire was demonstrated. THERE IS A BETTER WAY — DON'T LET IT HAPPEN.

As said before, what is true of the Twin Towers is true of many, if not all High-Rise Office buildings and will be applicable to varying degrees. On the other hand, what has been learned in high-rise office fires in New York City will certainly be applicable to the World Trade Center.

HIGH-RISE FIRE SAFETY

There are over 2,000 High Rise Buildings in New York City, excluding residential occupancies, of which 805 are Manhattan Office Buildings. It has been shown that about 170 fires will start in these buildings each year, most will be of no consequence. In 151 of these office buildings that are fully sprinklered, records show that in the past six years there were 85 fires in which sprinklers were called upon to extinguish the fire. Sixty-four of these were controlled by one head, eleven fires by two heads, six fires by three heads and single fires by four, five and six heads. There was only one failure which was caused by a shut floor valve. These fires occurred from the basement to the 34th floor.

The experience in New York City for almost 75 years shows that fires can be started from many different causes ranging from an Air Force bomber crashing into the Empire State Building, to a cigarette dropped into an overstuffed chair. Somewhere in between must be placed the incendiary device hidden in a reception room and welder's sparks that have been responsible for many fires. However, the list of spectacular fires in New York City for the fifty years from 1917 to 1967 were very few and the loss of life was essentially zero in all high-rise fires in this period. The exception, of course, is the plane crash, which sprayed about 800 gallons of gasoline on two floors but still did not jeopardize the strength of the building. Not all fires have been confined to one floor; the Woolworth Building had a grease duct fire that extended from the basement to the roof of the building; the Empire State had a fire in insulation around a water pipe in a shaft that spread fire from the 31st to the 66th floors, and fires in elevator shafts are relatively common. There were serious and unusual fires but they were readily controlled before reaching conflagration proportions.

However, in 1968 and early 1969, experience changed dramatically with the occurrence only months apart of the Time and Life Building fire that provided spectacular television shots: the Chemical Bank fire that frightened the occupants because of smoke penetrating many stories and the fire in an architects' office that killed ten occupants. The fact that this last fire was not in a high rise building, but on the 3rd floor of a small five-story, fire resistive building, heightened the concern of New Yorkers for their safety. The fires in 1970 at One New York Plaza and 919 Third Avenue, where a total of five people died, showed that the safeguards of the past no longer existed. From this realization was born the requirement of Local Law No. 5, previously mentioned. It was apparent hazards and deficiencies do exist in high-rise office buildings and the provisions of this law were to reduce or eliminate the danger to life.

What are the hazards today that were not present in the fifty-year trouble fire period?

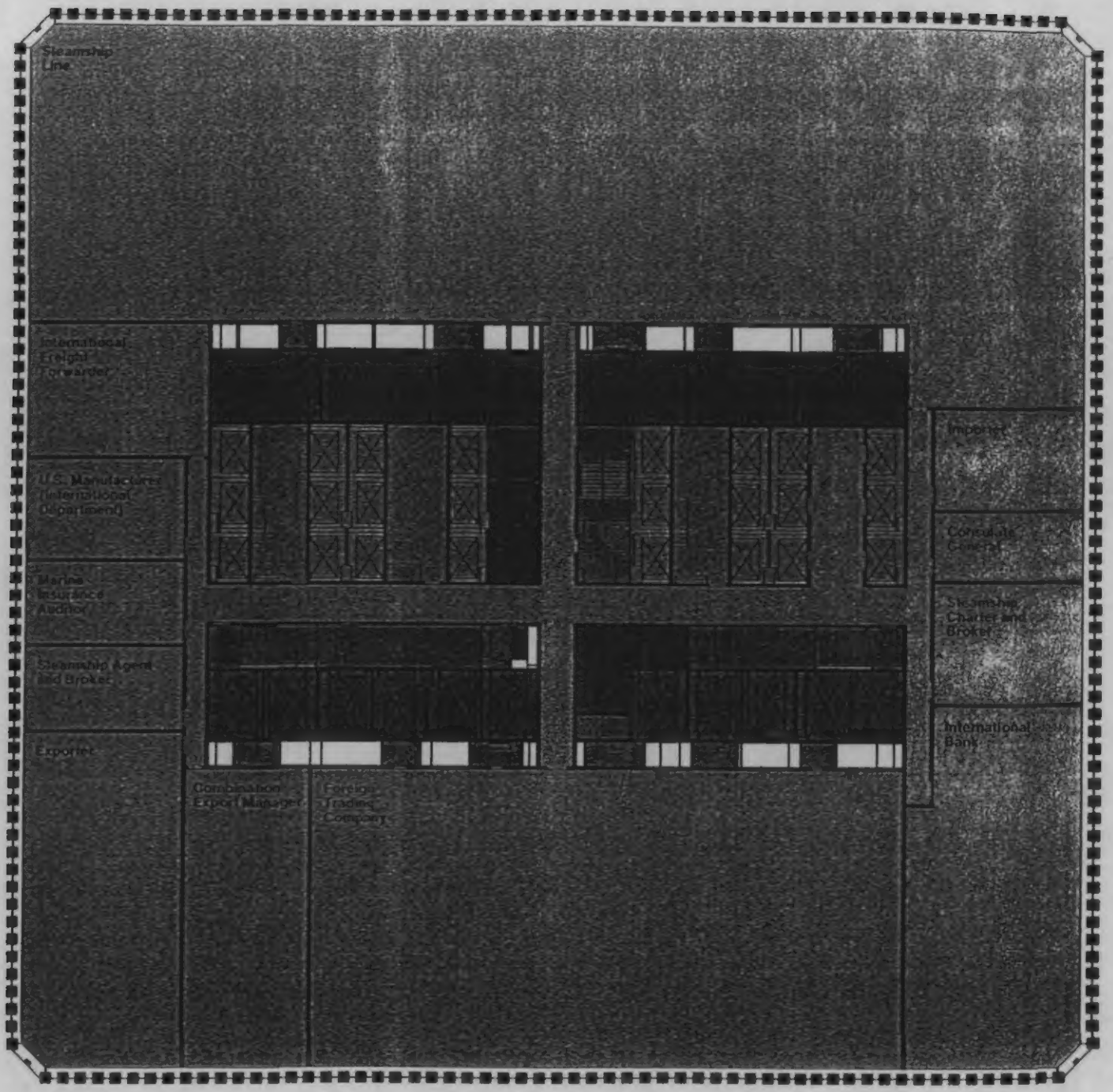
1. Combustible furnishings. In order to have a fire, it is necessary to have something to burn. The all-steel office of the 20's and 30's with steel desks, steel files, steel and glass partitions and masonry enclosed stock rooms are becoming a thing of the past. In their place, fashion dictates the use of overstuffed chairs, wood desks, combustible "landscape" partitions, combustible carpeting and combustible panelling or finish on the walls. The most serious aspect is that very highly flammable foamed polyurethane and foamed rubber cushioning is used which burns at an extremely high rate liberating flammable gases and copious smoke. Burning of this material is so rapid as to pose a threat to people in the immediate or nearby areas.

Not to be overlooked is the tremendous quantity of paper used in offices. Computer printouts use large quantities of paper and generate masses of used carbon paper. The storage of files on open racks, or cardboard cartons, can turn an office into a small warehouse. The reference libraries in lawyers' offices and drawing racks in architects' offices, create a severe fire-loading and have caused several serious fires.

It is recommended that where highly combustible material or large accumulations of combustibles are present and including shops or stores, automatic sprinklers should be provided.

2. Central Air Conditioning. The central air conditioning system of itself is not a fire hazard. It is of importance because of its ability to spread smoke throughout a building, to carry the fire from one section to another, and to intensify the fire. Smoke can carry through a system even when it is shut down and create intolerable conditions on other than the fire floor. The fresh air brought in by the air conditioning will tend to fan a fire and the drawing up of the air into the plenum can spread the fire in the direction of the return air shaft. It is because of this that no combustibles should be allowed in the plenum to create additional heat and additional problems. This tendency for fire to travel to the return air shaft can be an advantage if the shaft is of non-combustible construction and the smoke is discharged to the outside. This action will tend to prevent a build-up of pressure in the fire floor from the heated gases and lessen the spread of smoke in the building. Obviously, a shutter which closes off the air shaft will nullify this effect. Once again, if only a portion of a space is involved in fire, sufficient cool air will be carried along with the hot gases to moderate the temperature impact.

It is recommended that in unsprinklered buildings, detectors be provided at the return air shafts on each floor to cause it to discharge the return air and stop the



Plan of a typical tower building floor indicating areas occupied by

Key

- Express elevators to skylobbies
- Local elevators
- Freight elevators, service areas
- Rest rooms
- Electrical, janitorial and mechanical areas
- Stairs
- Storage areas

delivery of fresh air to the fire area, or if this is not feasible to shut down the air conditioning system. The popularity of air conditioning introduced another hazard — combustible insulation in the walls. Foamed plastics are excellent insulation materials but are extremely flammable. Tests have shown that exposed polyurethane foam on a wall can burn so rapidly as to outrun the fusing and operating of sprinkler heads. Such insulation should never be exposed in walls, shafts or concealed spaces but should always be enclosed by a non-combustible thermal barrier.

3. Design faults. Building Codes in general have requirements that will provide a reasonably fire-safe building. Tests by fire at impartial laboratories are conducted by manufacturers to prove their products meet code requirements. Unfortunately, no provision seems to be made for protection of openings in floors and walls. Consequently, some of the holes are not filled or others are filled with materials that disappear in the first seconds of fire. It is ridiculous to spend time and money to prove that a floor or wall can withstand a two-hour fire and then allow holes to be cut in it that destroys the fire resistance.

It is recommended that where openings in floors or walls are provided for air conditioning ducts, cables, pipes, or any other purpose, fire stopping or protection of the opening should be specified in the design. This protection and fire stopping should be subjected to the same tests as the floor or wall in which they are located to provide assurance.

There is another design fault in the creation of vertical shafts around columns in exterior walls, or in the exterior skin of the building. Such openings have allowed fire to spread from one floor to another where only flammable plastic foam served as a fire barrier to the shaft.

It is recommended that these voids have the same protection as all other shafts to maintain fire integrity between floors.

Another problem is the entire design of the modern light-weight building. Although the components have passed fire tests, they have provided no reserve for unexpected conditions. For example, a concrete block wall would be still standing and preventing fire spread long after its two-hour fire exposure. As a contrast, many modern assemblies would have disappeared only a few minutes after the duration of test fires.

Similarly, sprayed fireproofing has successfully passed fire tests but conditions in the field are not the same as in the laboratory. Even if the sprayed material is properly formulated and applied to the proper thickness, it may not adhere to the surface or may be knocked off as other building services are installed. The result is that the expected fire resistance is not there when it is needed.

In many discussions of protection of High-Rise Office buildings, much has been said of the trade-offs that should be allowed where automatic sprinklers are installed. The facts of life are that the trade-offs have already been taken in the modern design of buildings. The installation of sprinklers is the best way to return building protection to the level of the past.

The only other alternative is to provide a redundancy of protection as required by Local Law #5, minimize the fire hazards within the building, and constantly supervise the maintenance of building protection.

4. Communication and Power Wiring. The sheer bulk of the electrical and communication equipment in a major office creates a problem because of the number of wires and cables required to supply them. Where conduit or underfloor raceways are provided, the hazard is almost nonexistent. All that is required is fire stopping where the cables pass under or through power or telephone closet walls. Where trench header ducts are a part of the cellular steel floor support, fire protection under these ducts is needed to prevent heating of the insulation to its ignition point and igniting carpeting located over or adjacent to floor plates and outlets on the floor above. The worst and most hazardous condition is when wires and cables with combustible insulation are run through plenums to service the floor above. This provides a double hazard by introducing combustibles into the air conditioning and by requiring openings in the floor that are not equipped with fittings or fire stopping equivalent to the fire resistance of the floor. Telephone cables can carry more than messages, they can carry fire through a wall even when conventional fire stopping is provided. It should be noted, that the mass of cables to supply communication equipment in many office occupancies is sufficient to sustain a substantial fire. While an individual cable is extremely difficult to ignite, a group of cables lying parallel will burn intensely, similar to the situation that exists with a group of logs in a fireplace.

It is recommended that wiring installation be provided with tested fire stopping at shafts and walls. Trench header ducts should be provided with fire resistive protection on the underside to prevent transmission of fire to the floor above. Cellular branch ducts should also be protected unless floor outlets connected to them are provided with listed fire stopping.

A fairly recent development is the installation of telephone and communication equipment by other than the local telephone utility. This equipment may be located in storage or other areas than in telephone closets. This equipment and its wiring contains considerable combustible plastics and could be a source of fire.

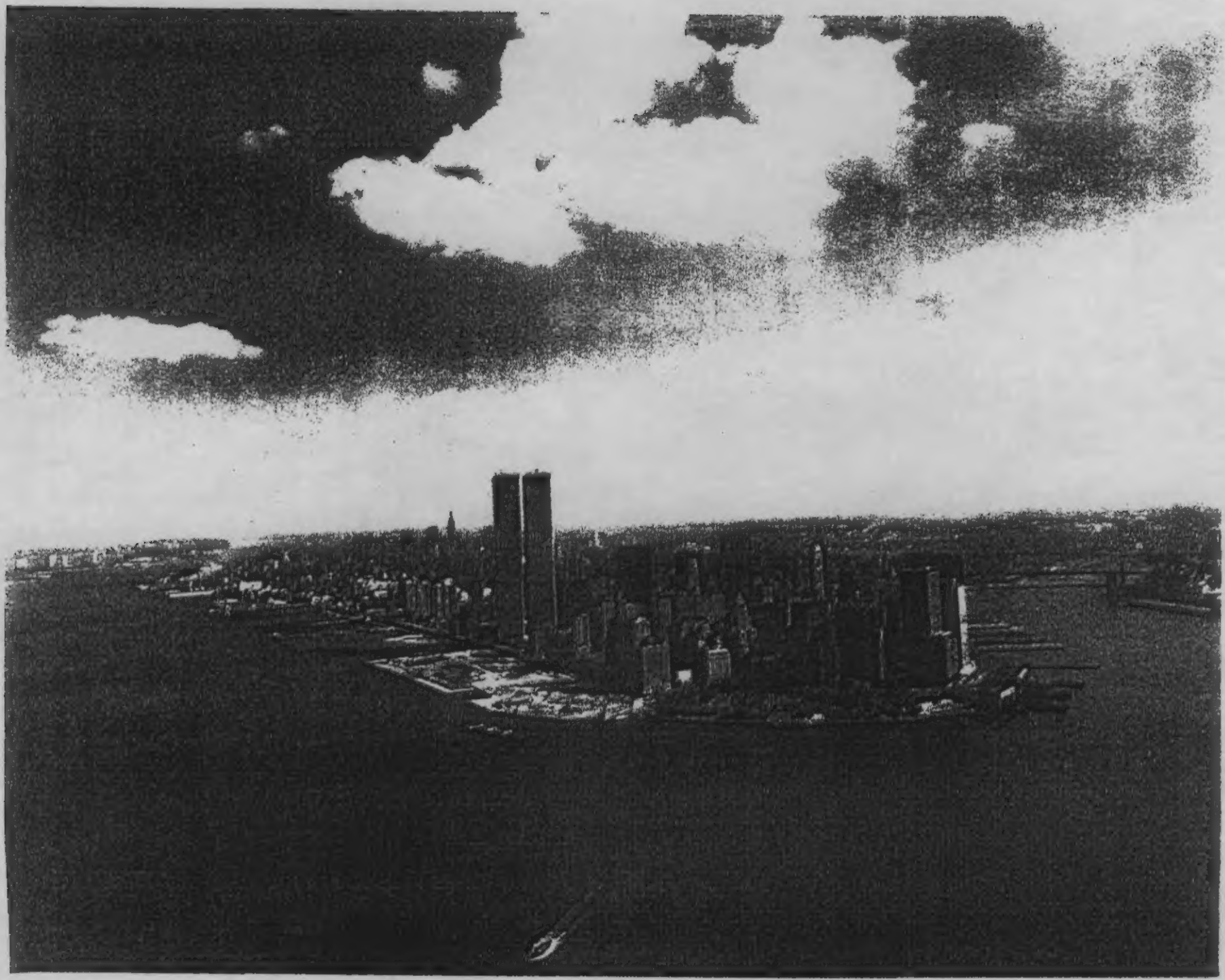
Telephone cables in plenum above hung ceiling. Note opening in closet wall.

The contention that telephone and other communication wiring cannot create a hazard because of low voltage and low amperage is not borne out by the experience in New York City. A substantial number of fires of electrical origin have occurred in telephone equipment in office buildings. In addition, faults of installation such as lack of fire stopping or installation in improper locations threaten the fire safety of buildings.

It is recommended that communication wiring and equipment be subject to the same inspection procedure and requirements for compliance with the National Electric Code as is required of power wiring.

5. Elevator Call Buttons. Finger sensitive elevator call buttons have been responsible for calling elevators to a fire floor. If the car is occupied, the riders are subjected to the fury of the fire when the doors open. The buttons can be operated by heat, smoke, flames, and other conditions present during a fire.

It is recommended that in an unsprinklered building smoke detectors be provided in the elevator lobbies to make elevators proceed directly to the ground floor. It is also necessary to have special "Fireman Switches" in the elevators to prevent their being called to the fire. floor when firemen are using the elevators.

6. Hazards of Construction. Many fires in New York City have shown that the fire hazards of a building which is still in the process of construction, but partially occupied by permanent tenants are serious. There is a dual control which makes it difficult to implement safety plans. There are operations and hazards that will not be present when the building is completed. Openings are left in floors for future electrical or air conditioning equipment; temporary elevator doors to accommodate large equipment are substandard or left open; protection is not applied to air conditioning ducts that pass through corridors; openings are not fire stopped in walls and floors; protective coatings are removed from structural steel; and large accumulations of combustible materials or combustible packaging are usually present. Alarm devices may be only partially operable or not yet accepted by the building owner. Welding, cutting, soldering, careless smoking can provide ignition sources. Basic fire protection features such as stairs, elevators, alarms and standpipes must be in service to the level of the highest tenant. Fire partitions around the tenants' space must be complete even if temporary fire stopping is necessary until work in the area is completed. Tenants should be acquainted with evacuation procedures, location of fire protection equipment, and most of all with information on hazards or hazardous areas to be avoided. Strict supervision must be provided to prevent hazardous operations that might endanger the tenants such as chopping holes in stair towers, welding adjacent to occupied areas or creating smoke conditions in air handling equipment. It is not possible to anticipate all of the hazards, but the precautions can be narrowed down to providing the tenants with totally enclosed fire-safe construction with no unprotected openings.

In conclusion, fire safety at the World Trade Towers, as in all other High-Rise buildings, is what the owner and tenants make it. The owner must provide an inherently safe building, competent personnel to maintain it and proper supervision of hazards in the building. The tenants have the obligation to be aware of the fire safety features and evacuation plans and to participate in drills. They, too, have the responsibility for the safeguarding of hazards in their operations, and in minimizing the effect of a fire in their premises. Such cooperation will make certain that no conflagrations, such as occurred in Brazil, occur in their building.